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AUTHOR Clark, Diane
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ABSTRACT

Prior studies have often confounded linguistic and perceptual performance when evaluating deaf subjects' skills, a confusion that may be responsible for results indicating lesser recall ability among the deaf. In this series of studies this linguistic/perceptual confound was investigated in both the iconic and short term memory of deaf individuals. Initially iconic memory was investigated using both familiar and unfamiliar stimuli. Results showed that deaf subjects (n=8) did not have deficits in visual perceptual abilities but had deficits in their linguistic skills. Deaf subjects also showed a practice effect with the familiar stimuli, an effect not found among the hearing subjects (n=8). In a serial position recall task deaf subjects were found to have lower levels of recall at all of the serial positions than did hearing subjects. Deaf subjects also did not show a significant recency effect. While results show that deaf and hearing subjects have comparable levels of skill in their visual information processing strategies, it would appear that the two groups use different kinds of input strategies that may not be optimally suited for recall of sequential information. (Author/PB)

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NEW METHODOLOGIES TO EVALUATE THE MEMORY STRATEGIES OF DEAF INDIVIDUALS

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Diane Clark
Department of Psychology
Mount Saint Mary's College

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Abstract

Prior studies have often confounded linguistic and perceptual performance when comparing deaf subjects' skills. This confound may be responsible for the kinds of results which show that deaf subjects recall shorter sequences of information and that they have specific deficits in auditory memory (Blair, 1957; see Cumming and Rodda (1985) for a review). When methodologies control for this linguistic and perceptual confound, deaf subjects have been shown to have comparable information processing strategies (Hartung, 1971).

In a series of studies by Clark (1985, 1987, 1988) this linguistic-perceptual confound was investigated in both the iconic and short term memory of deaf individuals. Initially iconic memory was investigated with a modified Sperling type task, using both familiar stimuli (English letters) and unfamiliar stimuli (low frequency symbols available on the ASC II codes of an IBM computer). Results showed that deaf subjects did not have deficits in their visual perceptual abilities (on the relatively novel stimuli) but had deficits in their linguistic skills (lower levels of recognition with the English stimuli). The other interesting finding was that deaf subjects showed a practice effect with the familiar stimuli (the second series of letter trials had significantly higher levels of recognition than the first series) while the hearing subjects did not show this practice effect (the first and second series of trials for this group had comparable levels of performance). A follow-up study (Clark, 1987) at Gallaudet did not show this practice effect. Deaf subjects in the 1987 study had higher educational levels and appeared to overcome difficulties with linguistic input. Therefore, it is possible that what was found was an experiential deficit as has been suggested by Liben (1978).

As was mentioned earlier, deaf subjects recall fewer items in sequential tasks and recently gathered data attempted to determine why this lower recall occurs. A serial position recall task was used with a visual display of the WAIS-R digit span tasks (the backward recall sequences). Digits were presented for one second at a time on the screen and moved across the screen in either a left-right order or a top-down order. The deaf subjects have lower levels of recall at all of the serial positions than did the hearing subjects. An interesting effect was that the deaf subjects did not show a significant recency effect. When collecting data, covert rehearsal was observed and this may account for why the last items presented were not preserved in immediate memory.

When linguistic and perceptual materials are carefully controlled, results show that deaf and hearing subjects have comparable levels of skill in their visual information processing strategies. It would appear that the two groups use different kinds of input strategies that may not be optimally suited for recall of sequential information. The results of the serial position

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recall study seem to suggest that unless we understand the preferred strategies of the deaf subject we may teach them hearing types of strategies that interfere with their natural abilities.

Introduction

Understanding deaf individuals' ability to process visual information is important in investigating their language abilities, since language input is received through this system. In some early studies of visual information processing, (Heider, 1940; Larr, 1956; Myklebust & Brutten, 1953; Olson, 1967), deaf subjects were found to have an apparent inability to perform as well as hearing subjects; a deficit attributed to problems in their visual perception. Many of these studies were attempts to understand why deaf people typically were severely limited in their reading abilities and one explanation was provided by alleged visual information processing deficits. Since the goal of this early research was to understand the deaf individual's poor reading skills, English stimuli were used in these studies. The deficits thus observed were often the result of a confound between perceptual and linguistic abilities.

Several studies have attempted to untangle thisconfound between deaf people's perceptual abilities and their linguistic skills (e.g., Blair, 1957; Siple, Hatfield, & Caccamise, 1978; Hartung, 1970). Investigations of this type typically have shown some differences between deaf and hearing populations, but they have not confirmed the earlier studies that always found deaf subjects deficient in visual information processing. When linguistic abilites are equated between deaf and hearing subjects, some researchers have found similar memory performance (Hartung, 1970; Morariu & Bruning, 1983). Other researchers have found a correlation between reading ability and the utilization of speech-based recoding strategies (Conrad, 1979; Lichtenstein, 1983). These kinds of studies suggest that deaf people may not have information processing deficits in comparison to hearing people but rather may develop different skills and strategies.

One important attempt to integrate the diverse results from the earlier research is Hartung's 1970 study where he suggested that the differences found in visual information processing between deaf and hearing individuals was a confound related to the stimuli that had been used in these prior studies. He suggested that visual perceptual skills of deaf children should be evaluated by using two types of materials: unfamiliar material that would assess their visual sensory abilities and familiar materials which would assess their information processing skills with regard to memory. This would allow an evaluation of the differences between perceptual abilities and information processing strategies.

Hartung (1970) pointed out that English letters, frequently used in studies of visual information processing, were not as overlearned for deaf subjects as they are for hearing subjects. He controlled for the confound between perceptual skills and linguistic skills by including a manipulation of stimulus familiarity in a tachistoscopic recognition task. He found that with unfamiliar input (Greek letters) deaf subjects could identify the items as well as hearing subjects, but with familiar language input (English letters) the hearing subjects showed a significant advantage. Hartung's findings of similar performance between deaf and hearing subjects for the unfamiliar stimuli suggested that prior research showed linguistic deficits not perceptual deficits.

Most information processing studies of deaf individuals have evaluated recognition and retrieval skills in both short term and long term memory. This body of research leaves the questions about the characteristics of the early stages of information processing or iconic memory in the deaf subject. Nickerson (1979) suggested the importance of evaluating the parameters of the visual system's information processing capabilities for language input, pointing out reasons for not assuming similar processing in the visual systems of deaf and

hearing individuals. He suggested that investigations of this type might lead to the development of strategies to remediate the reading performance deficits often found in deaf subjects.

To evaluate the physical parameters of deaf subjects' iconic memory, the duration of that memory was investigated. The 250 msec "fade" of iconic memory in comparison to the one second "fade" of echoic memory places constraints on how long language information is available for processing when the different systems are utilized. If deaf individuals' visual systems have been altered by early feedback in a structure-function type of interaction (see Gottlieb, 1975), one possible parameter for this change would be in the duration of iconic memory. To investigate this interaction hypothesis, three inter-stimulus intervals (ISIs) were included in the study: no delay, 250 msec, and 500 msec, post stimulus presentation. Findings of an increase in the number of correct trials at the 250 and 500 msec delays for deaf subjects in comparison to hearing subjects would lend support to this interaction hypothesis.

The second manipulation was one of stimulus familiarity. Both English letters and ambiguous symbols were presented in an attempt to untangle the prior confound between the perceptual abilities and linguistic abilities of deaf individuals.

Method

Subjects. Sixteen subjects participated in this experiment, eight deaf adults (ages 17 to 28 years, mean=20.5) and eight hearing adults (ages 18 to 26 years, mean=20.6). All eight hearing adults participated for credit in a general psychology course. Deaf adults were recruited from the community by a local interpreter who worked at the Guilford County Communications Center for the Deaf in Greensboro; six subjects attended a local community

college and the remaining two lived in the local area. All eight deaf subjects were prelingually deaf with severe to profound hearing losses (> 80 db in the better ear).

The criterion for subject inclusion was above chance performance on the letter stimuli in the no delay block. Only one deaf subject failed to reach an inclusion criterion, and was replaced.

Apparatus and Materials. An IBM Portable Personal Computer with an amber screen was used to display all materials and record the data. Eight uppercase English letters and eight ambiguous symbols were used as stimuli (see Figures 1 and 2[1]). The letter set was drawn from consonants of the alphabet so as to be maximally discriminable. The symbol set was drawn from other characters available as ASC II codes.

Procedure. Subjects were tested individually. Each trial consisted of the following sequence: The computer displayed a prompt to "press space bar for next trial." Next, the fixation point appeared in the middle of the computer screen and remained for one sec. This fixation point was followed by the stimulus array, which consisted of a circular array of either the eight letters or symbols. Placement of the eight letter or symbol stimuli within each circular array was randomly generated by the computer. The stimulus array remained on the computer screen for 150 msec. The array was followed by an asterisk which was used to cue subjects as to which position to recall. Placement of the asterisk (i.e., determination of a target) was randomly generated by the computer and the asterisk was located on a cleared screen behind the prior position of the cued stimulus. Depending on the ISI of the specific trial (presented in blocks of 20), the asterisk followed the array either immediately or at ISIs

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[1] Figures are placed at the end of the article before references.

of 250 or 500 msec. The asterisk remained on the screen for 1 sec. Trials were self-paced and all trials were identical.

Three blocks of 20 trials each were presented. One block at no delay, a second block at the 250 msec ISI and the third block at the 500 msec ISI. Order of the three blocks was randomly generated by the computer. Two series of the three blocks were presented for each stimulus type (120 trials per stimulus type). The first series was a practice series to acquaint subjects with the task and the second series was to test recognition after exposure to the task.

Order of stimulus presentation was either letters then symbols or symbols then letters with a 2 minute delay between each of the stimulus types. Order of presentation was counterbalanced across subjects with one half of the subjects receiving the first presentation order and the remaining half receiving the second presentation order.

Responses were prompted by the statement, "Respond using keys at left" appearing on the screen. Eight of the function keys on the IBM, to the left of the space bar, were programmed to serve as response keys. An overlay was placed on these keys to identify which key corresponded to each of the stimuli. The subject's task was to identify which of the stimuli had been at the cued location and press the appropriate response key. Subjects were encouraged to respond as quickly as possible but response times were not recorded. The next trial started immediately after the subject's response was keyed in with the statement "press space bar for next trial".

Stimuli were 2.4 log units above the background stimulation of .44 ml. The subject sat approximately 41 cm from the screen, so that the stimulus display subtended 3.7 degrees of visual angle. Each individual stimulus subtented .6 degrees of visual angle.

The predictions for this experiment were as follows: a)hearing subjects would show an effect of stimulus familiarity with letters having higher recognition scores than symbols, b)deaf subjects would not show an effect of stimulus familiarity (i.e., equivalent scores between the letters and symbols), c)recognition scores for symbols would be equivalent between deaf and hearing subjects and d)deaf subjects would show a structure- function interaction in that their iconic memory would be longer than hearing subjects (i.e., higher levels of recognition at the 500 msec ISI).

Results and Discussion

The present experiment had two between-subject factors (hearing status and order of stimulus presentation) and three within-subject factors (series, stimulus type, and delay of cue presentation). A split plot analysis of variance as well as planned comparisons were performed on the recognition scores (i.e., the number of correct responses within each block of 20 trials). For clarity, analysis will be presented in terms of the within subject factors. Unless otherwise noted, all effects described were significant at or beyond the .05 level.

Series. Overall, hearing subjects had significantly higher recognition scores than deaf subjects, $F(1.12)=5.00, MSe=9.79$. There was an overall significant practice effect, $F(1,12)=17.33$, $MSe=3.31$, but planned comparisons showed that the only significant increase in performance was between the deaf subjects' two series in the letter condition, $F(1,12)=2.50$. Hearing subjects showed no difference in their recogntion scores for letter stimuli betwen the two series.

The practice effect found with letter stimuli between the first and second series for deaf subjects suggests that both deaf and hearing subjects were capable of comparable performance with English stimuli when deaf subjects were allowed sufficient practice. Hearing subjects did

not show a practice effect, suggesting that English letters were overlearned for this subject group. Deaf subjects, on the other hand, attained significantly higher scores on the second series, suggesting that English letters were either not as familiar to this group as they were to the hearing group or required practice to be rapidly recoded into an acoustic code.

Stimulus Types. A main effect of stimuli was found, $F(1,12)=27.43$, $MSe=6.09$, with letters being recognized significantly more that symbols. In addition, there was a significant interaction of order with stimulus type, $F(1,12)=19.00$, $MSe=6.09$. Newman Keuls analyses revealed that when letters were followed by symbols, recognition scores were not significantly different (symbol mean=4.81, letter mean=5.13). With the reverse order of presentation, symbols followed by letters, a significant difference in recongition scores occurred (letter mean=6.85, symbol mean 3.44) (see Figure 3). Both deaf and hearing subjects showed this same pattern of responding. This effect appears to be related to a contrast in labelability in which unfamiliar stimuli effect later performance on familiar stimuli. When familiar stimuli were presented first, it appears that subjects were able to adopt a coding (labelling) strategy that was not readily available when unfamiliar stimuli were presented first.

Planned comparisons revealed that hearing subjects had significantly higher recognition scores on the letter presentation than on the symbol presentation (see Figure 4). In comparison, deaf subjects did not show an overall significant letter-symbol difference. These results confirm the first and second predictions made above, i.e., that hearing subjects would show an effect of familiarity while deaf subjects would not.

Planned comparisons revealed no significant differences between deaf and hearing subjects recognition scores in the symbol condition, thus confirming the third prediction that no differences would be found between the groups with ambiquous information. Neither subject

group had significant differences between the two series, therefore, no significant practice effects occurred for the symbol stimuli.

Delays of Cue Presentaiton. In evaluating the effect of the three ISIs, a significant main effect was found, $F(2,23)=6.77$, $MSe=2.82$. Higher levels of correct responses were obtained at the 250 msec delay than at either the 0 delay or the 500 msec delay.

One possible explanation for the superior performance at 250 msec is that the delay may be the optimal time interval for this particular task: at 250 msec, information is assumed to be transferred out of iconic memory for further processing, but at the same time the stimulus display is still available in iconic memory. Therefore, if the item has not already been transferred, it can still be retrieved from iconic memory. In the no delay condition, only iconic memory processes are available for outputting information. At a 500 msec delay, only information that has already been transferred is available for output. Thus, the advantage seen at 250 msec may be related to a combination of the availability of the stimulus array as well as a subset of items having received additional processing and thus having a higher probability of being outputted.

Comparisons of deaf and hearing subjects at all delays revealed no significant differences in the number of correct responses at any ISI. This finding suggests that the early stages of deaf and hearing subjects perceptual processing, or iconic memory, appear to be comparable.

Analysis of Position Effects. One source of information concerning processing strategies used by deaf and hearing subjects was an analysis of position effects (e.g., number of correct responses at each position within the circle array (see Figure 5 for numbering of each position)). Two split plot analyses of variance were performed on the number of correct responses at each stimulus position, one for letter stimuli and one for symbol stimuli. Each

analysis had two between-subject factors (hearing status and order of stimulus presentation) and two within-subject factors (series and stimulus position).

As can be seen in Figures 6 and 7, a significant hearing status by position interaction occurred in both letter presentation, $F(7,84)=2.96$, $MSe=3.68$, and symbol presentation, $F(7,84)=4.48$, $MSe=1.84$. Newman Keuls analyses revealed that hearing subjects' scores on the letter presentation at positions 2 and 6 were significantly better than at all of the other positions except position 3 ($p=.05$). Positions 2 and 6 were on the horizontal, to the right and left of fixation and appeared to benefit from a tendency in hearing subjects to scan left to right. Deaf subjects showed no significant differences in their scores at the different positions though scores for positions 0, 1, 2, 6, and 7 were elevated. These elevated positions correspond to positions in the top half of the circular array. These differences in the pattern of correct responses may be showing strategy differences in information processing styles.

Both deaf and hearing subject groups showed the same general patterns of responding in the symbol presentation as they had in the letter presentation. Newman Keuls tests revealed a similar pattern of significant differences, in that hearing subjects had better scores at positions 2 and 6 while deaf subjects had no significant differences among the positions though scores at positions 0, 1, 2, 6, and 7 were elevated. These results suggest that similar recognition scores do not require similar information processing strategies in deaf and hearing subjects.

In summary, three of the four predictions for this experiment were confirmed. (1) Hearing subjects were found to show a significant effect of stimulus familiarity, with overall higher recognition scores for letters than for symbols. (2) Overall, deaf subjects showed no significant differences between their recognition scores on letter and symbol presentations. (3) Hartung's (1970) suggestion that prior studies had confounded perceptual and linguistic abilities

was supported; ambiguous symbols, which precluded tapping prior linguistic skills, produced non-significant differences in performance between deaf and hearing subjects.

The prediction of a structure-function interaction in the time parameter of deaf subjects' iconic memory was not supported. The similarity between deaf and hearing subjects' recognition scores at each of the three ISIs suggested that the time parameters of their iconic memories were similar. An apparent strategy difference was found between the deaf and hearing subjects, however, as reflected in the analyses of position effects. Deaf subjects appeared less dependent than hearing subjects on a left to right scan for dealing with input of visual information but rather appeared to use a strategy of scanning a whole area.

This last analysis lead to questions about the kinds of input strategies that deaf subjects were using. The analysis of position effects showed that even when deaf and hearing subjects had comparable recognition scores they were using different strategies. These results lead to questions about why these differences had occurred. Were the differences related to experiential deficits as suggested by Furth (1966) and Liben (1978) or were they related to the educational background of the deaf subjects? A second experiment was conducted to evaluate these questions.

Two manipulations were included in Experiment 2. The first looked at whether or not the age of sign language acquisition effected the types of information processing strategies that deaf individuals use to input visual information into iconic memory. Four groups of subjects were used for this manipulation: subjects from oral school backgrounds, subjects from manual (signing) school backgrounds, hard of hearing subjects, and hearing subjects who learned sign language from deaf signing parents. The second was to investigate whether or not different ISIs effect the kinds of information processing strategies used by deaf subjects.

Method

Subjects. Twenty-four subjects from Gallaudet University participated in the experiment. Six subjects were from oral backgrounds (mean age=24.8). Six subjects were from manual backgrounds (mean age=23.7). Six subjects were hard of hearing (less than a 65 db hearing loss) (mean age=26.1)). The final 6 subjects were hearing staff or faculty from the university who had signing deaf parents (mean age=37.6).

Apparatus and Materials. A Compac portable computer with an Amdek screen was used to collect the data. Materials were the same as in Experiment 1.

Procedure. The procedure was the same as in Experiment 1, with the exception of the ISIs. ISIs in the present experiment were: 50 msec, 150 msec, and 250 msec.

Results and Discussion

This experiment had two between subject factors (subject group and order of stimulus presentation) and three within- subject factors (series, stimulus type and delay of cue presentation). A split plot analysis of variance was performed on the recognition scores (i.e., the number of correct responses within each block of 20 trials).

Series. The prediction that age of sign language acquisition would effect the information processing strategies in this task was not supported experimentally. There was no effect of oral versus manual background. The only significant differences between the groups was in an interaction of educational group by order by interstimulus interval ($F(4,24)=2.63$, $MSe=2,4.$) In the letter/symbol condition, the manual subjects were better at all three ISIs but this advantage was lost in the symbol/letter condition. This finding may suggest that subjects who grow up knowing sign language have some differential advantages that were not detected in this taskas a main effect, but further investigation is need to clarify this point.

Subjects in this experiment did show effects of familiarity, such that the letters had significantly higher scores than did the symbols ($F(1,12)=25.3$, $MSe=4.6$.) There was also an interaction of stimulus type with order of stimulus presentation,($F(1,12)=73.6$, $MSe=4.6$.) where in the letter/symbol order of presentation there were no significant differences between the stimulus types but in the symbol/letter order of presentation the letters had significantly higher levels of recognition. This combination of findings again suggests that familiarity effects can be masked depending on the order of stimulus presentation.

This same pattern of stimulus familiarity was found for hearing subjects in Experiment 1, but not for the deaf subjects. The major subject difference between the two studies is that the deaf subjects in this study were full time students at the only liberal arts college for hearing impaired students while in the prior study the deaf subjects were enrolled in a junior college. This educational difference seems to be related to a self selection process where better (or maybe more serious students) elect to leave home and attend a four year college rather than enroll in a local two year program. This finding would suggest that this is an experiential deficiet, as has been suggested by Liben (1978) and Furth (1966). It would appear that better students can perform at levels which match hearing students performance and past findings of inferior performance are due to comparisons with groups that have different levels of familiarity with the stimulus information (see Liben and Drury; 1977.)

Analysis of Position Effects. A multifactor randomized design was performed on the level of recognition at the different positions of the stimulus array. The three deaf educational groups (oral, manual, and hard of hearing) were compared at the eight different stimulus positions. There was a main effect of position ($F(7,96)=12.3$. $p > .001$) where positions 2 and 6 had significantly higher levels of recognition than the other positions. This pattern of

responding is similar to that found for the hearing subjects in the first study. This particular pattern of responding appears to be related to a reading strategy, where information is scanned in a left to right fashion. It is interesting that this pattern is also found in this group of deaf subjects and suggests, I think, that when presented with English stimuli in a complex task deaf subjects use a left-right sequential scan in processing the information. One interesting finding was that when informally asked to match the symbol set on the computer screen to the drawn symbols on the function keys a left-right strategy was not employed. When matching these two symbol sets the deaf subjects used a top-down scan, trying to match the information on function keys 1, 3, 5, 7, followed by 2, 4, 6, 8. This kind of a top-down strategy is presently under investigation in an attempt to better understand the information processing strategies optimally suited for presentation to deaf subjects.

General Discussion

Taking the two studies together, it appears that there are differences within the hearing impaired population in regards to the types of information processing strategies employed across tasks. Those who have well developed reading skills will use a sequential input strategy in complex tasks, even though they do not use this strategy in more informal tasks. It would seem that deaf subjects are capable of demonstrating equivalent levels of performance even is they utilize different information processing strategies. Interestingly, when comparing the levels of recognition of the hearing subjects in Experiment 1 to the levels of recognition of the deaf subjects in Experiment 2 one finds higher levels of performance for the deaf subjects. Therefore, not only are deaf subjects with equivalent levels of stimulus familiarity similar to hearing subjects they may actually demonstrate higher levels of performance.

When evaluating deaf subjects it is important to consider their levels of familiarity with the stimulus involved in the task. Deaf subjects show wide variability in this familiarity, even though they may demonstrate comparable skills in other cognitive capacities. Again, one must urge caution when investigating diverse subjects groups due to the competence- performance distinction. When investigating special populations, one must chose or develop methodologies that take into account the competence-performance distinction and not evalute all populations as if they were directly comparable to a traditional subject population.

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